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## ***Deliverable D1.4*** **Research and Teaching Map Report**

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# 1 Executive Summary

Deliverable D1.4 reports on the achievements and results of the first nine month period of the second phase. Since work package 1 is also call-based, the deliverable reports the current status of all funded projects, and the results achieved during the reporting period which are:

- PhD database
- EMIN (EMANICS Integration Reporting Tool)
- Worldwide Research Map
- Taxonomy on Network and Service Management
- Common Course Program resp. a curriculum for the PhD and MSc level with additional course material.

The first topic reported refers to the description of the concept and implementation of the EMANICS PhD database, in collaboration with work package 4, to strengthen the collaboration between partners and stimulate also joint PhD committees.

The development of EMIN (EMANICS Integration Reporting Tool) was focused on the integration with the grant application system, developed by UPC, and with the objective to avoid that the same data needs to be entered several times. Another aspect was the analysis and access to several data sources (e.g., quaterly management reports, the funded project proposals (which are the results of the call-based model), the IMT tool as provided by the coordinator CDC, the grant application system) in order to make them available for EMIN. The deliverable reports on first implementations and results.

Started from the initial idea of just visualizing research interests, the objective of the worldwide research map has been extended during the discussions to report also on current and planned projects as well as conferences researchers are involved. The WwRM should thus ease and stimulate collaboration within joint projects, joint PhD committees, and joint publications. Therefore, it was necessary to extract resp. access data from the JEMS conference system on one side, and to allow a flexible and especially easy way of adding and updating data manually by the researchers on the other side. A first implementation with Google maps has been realized and was presented at the work package meeting in January in Barcelona.

To develop a taxonomy of network and service management, a top-down as well as a bottom-up approach have been taken. During the WP1 meeting in Munich, a top-down approach has been taken to define the important terms of network and service management. The bottom-up approach mainly consisted of analyzing the data in the JEMS conference database about the topics of interests researchers have entered for several conferences. The deliverable reports on the outcomes of the analysis and the conclusions out of the bottom-up approach. Although not thought of it in the beginning, the scope of the taxonomy has been extended beyond EMANICS. The defined taxonomy resp. ontology should serve also for other purposes such as for e.g., IFIP classification.

The initial curriculum for the network and service management for the MSc level was defined. The structure and the content are also described in this deliverable.

## 2 Introduction

For the second phase, the NoE changed to an open-call based funding scheme for all work packages. This proved to be a very good decision as proposals with a concrete project description and timeline have to be submitted in order to get funding, and this fosters also integration and information exchange amongst the EMANICS partners.

In this deliverable we present the current status and achieved results of all funded projects in work package 1:

### 1. **PhD Database** (Task 1.1: Research observatory)

Partners: UPC, UT

The PhD database was designed to make PhD students within EMANICS aware of the work done by their colleagues. This contributes to strengthen the collaboration between partners and facilitates the integration as one main goal of the NoE. It also shows joint PhD committees and therefore documents them as well as this collection of information about PhD projects in one place fosters joint PhD committees. This is a joint project with work package 4, which has been continued from phase I.

### 2. **Worldwide Research Map** (Task 1.1: Research observatory)

Partners: UT, UniBwM

The worldwide research map represents a thematic mapping of research topics and assignment of experts to and within each topic not only for the current research but also serves as a focal point for further interesting topics. An initial step to identify current and future fields of research of the European research activities regarding IT management topics within the NoE was done in WP1 in the first phase. Based on this, the worldwide research map has been useful for conference managers to find reviewers for papers in conference management systems as well as for researchers to find related work from research groups quickly and to find cooperation partners for research projects.

One task was devoted to the integration of the worldwide research map with the JEMS system that is widely used for conference organization and holds valuable data about topics of interest for researchers worldwide. It is useful to update automatically data about previous, current and future projects as well as relevant journals, workshops, meetings and seminars. Those topics of interest have also been harmonized with the taxonomy on network and service management.

Besides, it was important to establish a long-term process to acquire, update and validate the information about research and teaching activities in the worldwide research map.

### 3. **Extension of EMIN (EMANICS Integration Reporting Tool) and Integration with the Grant Application System** (Task 1.1: Research observatory)

Partners: UniBwM, UPC

EMIN is a tool developed in WP1 phase I as a reporting and visualization tool of various integration metrics. In phase II EMIN has been extended in order to incorporate experiences from phase I. Furthermore, integration with the grant application

system, developed by UPC was performed, in order to share common data, and to omit to enter the same data several times.

**4. Taxonomy on Network and Service Management** (Task 1.1: Research observatory)

Partners: UT, JUB, UniBwM

Ontologies are a means of representing knowledge in a formal and structured way, so that the semantics of exchanged concepts are commonly known between all involved parties. We refined the problem space and the semantics of the management activity by developing a taxonomy (ontology) for network and service management. This has been a follow-up on first discussions by WP1 partners in March 2007. The involved partners will further refine the taxonomy and try to incorporate the NoE's knowledge on network and service management to popular information portals like wikipedia, standardization bodies and the like.

**5. Common Course Program** (Task 1.3: Common Course Program & Mobility Support)

Partners: UniBwM, JUB, UniZH, UT, LMU

One of the main tasks of WP1 in the second phase is to create a graduate curriculum (PhD, MSc) at different levels. This fosters a common level of knowledge amongst EMANICS partners. The partners mentioned above created a first draft of a CCP at Master's level in a combined effort at a meeting in Munich. This has been circulated to all EMANICS partners for comment and in a second step received feedback was incorporated. The structure that has been designed in this project helps to see which necessary courses are already taught at a partner's institution and where there is a lack of existing modules.

**6. Course Material: Economic Management - Charging and Accounting of IP Services** (Task 1.3: Common Course Program & Mobility Support)

Partners: UniZH, UniBwM

The work was to develop a new module for the Common Course Program (CCP). The module highlights economic management view points and complements other modules of the CCP, thus it has been placed as module 12 in the structure.

This deliverable reports about projects 1 to 5 in respective chapters. Project 6 is included in chapter 7 and the complete course material will be delivered with the final report on the CCP in Deliverable 1.5.

### 3 Ph.D. Database

The purpose of creating a PhD database was to make PhD students within EMANICS aware of the work done by their colleagues. This would contribute to strengthen the collaboration between parties and to facilitate the integration aimed at the objectives of this NoE.

#### 3.1 Conception and design

The requirements were quite simple. First of all, the information to be provided for each PhD thesis should be the essential to allow other people to understand the research scope, objectives and main technical approach as well as to offer the main results attained up to the moment. The second requisite was to facilitate students the easiest and most pragmatic mechanism to update the information. We have to keep in mind that although the thesis scope can be known relatively early in the process of a PhD execution, the objectives, technical approach and especially the results may vary throughout the whole thesis lifetime.

In order to cope with the first objective, we designed a template consisting of four fields that we would invite students to fill in. Figure 1 shows the respective template.

**Identification data**  
Title:  
Author:  
e-mail:  
Partner:  
Supervisor:  
Committee:  
Year of start:  
Year of end:  
Funding institution:

**Abstract:**

**Related papers:**

**Additional Information:**

Figure 1: Template of information from each PhD student

Beyond the basic guidelines fixed by this template, the student is allowed to include links to other information; for instance, the student could use his name to link the above template to his own personal web page. The *Abstract* is recommended not to exceed one A4 page, 12 p case. The *Related papers* field is intended to allow for listing the papers published in connection with the thesis. Here again the student can provide links to allow the reader to get such papers. Finally, the *Additional Information* field is completely open.



Based on the above described template, the database would consist of as many pages (instances of the template) as PhD students registered in the NoE. Therefore, it was necessary to integrate an indexing mechanism to facilitate the browsing process. Indexing was considered to be based either in the name of the student, in the title of his/her thesis and in his/her partner acronym. Also, search by topic was considered a good point but this would require first to define research scope topics commonly accepted by the community. As this is part of the activity of WP1 and it is not yet concluded, we decided to postpone indexing by topic for a future release.

## 3.2 Implementation alternatives

Keeping in mind that EMANICS uses Joomla as Content Management System (CMS), the first alternative was to consider it as the supporting mechanism. Other alternatives considered were a direct implementation on a database like MySQL and finally, the use of a wiki. In the following paragraphs we succinctly describe each alternative and finally present the reasons for the adopted one.

A Joomla based solution would require the creation of static pages, say one per student, and allow users to edit content on it. This would work for a few students but for a number of several tenths, as it is the case in EMANICS, this would be very complex to manage. Another alternative would be to get rid of the file upload facility offered by this CMS. This solution would require creating only one static page, say with the shape of a table where each row would be a record of one student. Then, the users would be able to insert their basic data in one row and one of the elements of this information would be a link to a file that would be uploaded into the system. Although feasible, this solution was considered to be too rigid and cumbersome. We have to say that this second alternative was in fact implemented and for some time it was tested by a group of people within WP4, but finally the results were disappointing especially in regards of the second requirement as described in the above section.

A real database implementation was very appealing especially in terms of support of search mechanisms. Content in the database could be retrieved by author, by partner, topic or any combination. Users could also have a good support to insert and maintain the information. We could think in a template based approach where the user would be asked to insert data fields or any textual information. Unfortunately, the price to pay in this approach is the design of the interface. This could be done in PHP or a similar language but it would require time and resources. In addition, perhaps the power of such a flexible mechanism would even be not justified considering the volume of information we are talking about. Keeping this in mind but specially the need to provide the resource as soon as possible, we discarded this option as well.

Wiki based solutions are well known today as an easy mechanism to publish on the Web. In this case, users could create their own pages quite straightforward and the syntax to use is not a problem assuming that you provide a template that is used as reference; just substituting the information contained in the different fields of the template the work is done in practice without any knowledge of the wiki syntax. In summary, wiki was promising in terms of easy maintainability. Also, the wiki was really fast to set up (it is a process of installing a software package). Nevertheless, the main drawback of this solution was the

need to integrate it in the web site. In fact, a stand-alone solution would be troublesome because of additional authentication and interfaces. After some search, we concluded that our Joomla based web site would allow us to integrate DokuWiki<sup>1</sup>, a general purpose project management wiki. This was finally the solution we adopted.

### 3.3 Current structure and content

The PhD database is structured in pages of DokuWiki. An index page contains the indexing information that currently is the partners acronym, the name of the author and the title of the PhD thesis. Figure 2 shows the first part of the index page. Names of authors are organized in alphabetic order within each partner. A total of around 40 authors exist today. The title of the thesis is a hyperlink to the page that contains the information of the template of Figure 1. Therefore we have at least as many pages as PhDs and an additional index page.


People wishing to add content (add a new page in case of newcomers, or modify an existing one) have to be registered as users of the Members Area of the EMANICS Site Administration. Non registered people can access the information with read-only rights. For any user's category, access is through the button PhD Theses of the main menu of the EMANICS site. This sends the user to the index page of the wiki.

Registered users are allowed to edit the index page to introduce/modify their own records and also their respective pages. Details of the edition procedure are provided in a document in the internal collaboration environment<sup>2</sup>.

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<sup>1</sup><http://wiki.splitbrain.org/wiki:dokuwiki>

<sup>2</sup><https://svn.man.poznan.pl/projects/emanics/attachment/wiki/wp4/Guidelines%20to%20edit%20the%20resource%20of%20Emanics%20PhD%20theses.doc>



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### PhD Theses within EMANICS

Summary of completed and ongoing PhD Thesis within EMANICS:

Partner: CETIM  
 Author: Samah Bel Haj Saad  
 Title: [QoS-Aware Fault Tolerance in Grid](#)

Partner: CETIM  
 Author: Frank Eyermann  
 Title: [A Multidomain Auditing System for IP-carrying SLAs](#)

Partner: CETIM  
 Author: Matthias Goehner  
 Title: [A service-oriented accounting system for dynamic Virtual Organizations](#)

Partner: CETIM  
 Author: Iris Hochstatter  
 Title: [Accounting in Context-based Systems](#)

Partner: HIO  
 Author: Siri Fagerness  
 Title: [System Administration and Emergent Properties of Pervasive Computing Environments](#)

Partner: IC  
 Author: Changyu Dong  
 Title: [A Non-monotonic Trust Management System with Privacy-Preserving Credential Verification](#)

Partner: IC  
 Author: Alberto E. Schaeffer-Filho  
 Title: [A Self-Management Framework for Pervasive Systems](#)

Partner: IC  
 Author: Themistoklis Bourdenas  
 Title: [Self-Healing Wireless Sensor Networks](#)

Partner: IC  
 Author: Eskindir Asmare  
 Title: [Self-Management Framework for Unmanned Autonomous Vehicles](#)

Partner: INRIA  
 Author: Humberto Abdelnur  
 Title: [Security architectures for services of voice over IP](#)

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Figure 2: Part of the wiki index page within the EMANICS web site

## 4 Extension of EMIN (EMANICS Integration Reporting Tool) and Integration with the Grant Application System

The work as reported in [1] concentrated on the development of integration metrics resp. indexes to evaluate the present collaboration among EMANICS partners. An initial integration report of all work packages in terms of the basic indicators is provided on the EMANICS web site. However, extensive work will be done on this topic in the future since there have already been a lot of discussions so far.

As a result of the first phase, the possibilities of the integration of EMIN with the grant application system, as developed by UPC, were discussed in order to avoid the necessity to enter the same data several times. Besides, an analysis of the various data sources (e.g., IMT, quarterly management reports, grant application system, funded calls) has been performed to obtain the requested information about the integration. Various aspects of the visualization have been discussed as well. It was decided to visualize the integration level with the size of the nodes and the thickness of the edges between the nodes that represent the partners. The integration is shown on the work package level and can be visualized also on the task level. The following indicators have been selected to measure the integration within the network:

- **Joint funded projects:** Counts the number of subtasks of the work packages in which the partners participate. This is measured per person months.
- **Joint published papers:** Gives the number of papers which are written by at least two partners and have been published.
- **Mobility:** Reflects the duration of a meeting of at least two EMANICS partners, counted in days of the visit.
- **Joint PhD committees:** States the number of inter-organizational supervisions of Ph.D. theses.
- **Other joint tasks:** Indicates dissemination or common activities with the industry and general collaboration; measured in person days, exchange programs, etc.

The deliverable includes some examples of the integration graphs.

The grant application system and EMIN are two web applications developed by UPC and UniBwM respectively that make use of data facilitated by EMANICS participants for different purposes. The former is aimed to facilitate users to apply for on-demand funding, whereas the latter is intended to quantify the level of integration throughout the NoE by assigning specific indexes to the activities carried out by the EMANICS participants. Obviously, a subset of input data of both applications overlap and it was decided not to ask people to enter the same data twice, but to facilitate that both applications share the same data repository.

Unfortunately, as both applications were developed independently, neither the data format nor even the database versions were the same. Therefore, it was necessary to carry out an adaptation process to facilitate the final integration of both data repositories. The technical

solution used was replication. Replication enables data from one database server (called the master) to be replicated to one or more other database servers (slaves). Replication is asynchronous, this means that the slave database does not need to be connected permanently to receive updates from the master, which means that updates can occur over long-distance connections.

The reasons to adopt replication were the following:

- **Data security** - because data is replicated to the slave, and the slave can pause the replication process, it is possible to run backup services on the slave without corrupting the corresponding master data.
- **Analytics** - live data can be created on the master, while the analysis of the information can take place on the slave without affecting the performance of the master.
- **Long-distance data distribution** - with replication a local copy of the data can be created without requiring permanent access to the master.

The first problem faced was a compatibility problem in the versions. The binary log format as implemented in MySQL 5.1 is considerably different from that used in previous versions, especially with respect to handling of character sets and time zones. As a general rule, replication can only be conducted between masters and slaves running the same major versions (5.1, 5.0 or 4.1) of MySQL. In case of different major versions, client version must be equal or higher than the master's one.

The second issue was the available information in the grant application system which is as follows:

- Conference & summer school attendance grant
- PhD committee grant
- Mobility grant
- Standardization meeting attendance grant
- Tutorial and training setup support grant

An analysis of the available data has shown that some of the data can be used directly in EMIN (e.g., PhD committee grant information), but that some required data in EMIN is missing in the grant application system (e.g., the number of days or hours for the application of a mobility grant). Thus, it was necessary to access also several other data sources such as the IMT.

During the implementation of the integration several problems especially related to the first indicator called *joint projects* have been encountered. This indicator counts the number of subtasks in the work packages in which the partners have participated. Due to the open call-based model, information about funded projects as well as the contributed persons per month per partner has to be addressed.

Fig. 3 shows the number of joint papers, Fig. 4 and Fig. 5 show EMANICS integration on work package level and Fig. 6 depicts the integration within all EMANICS work packages.

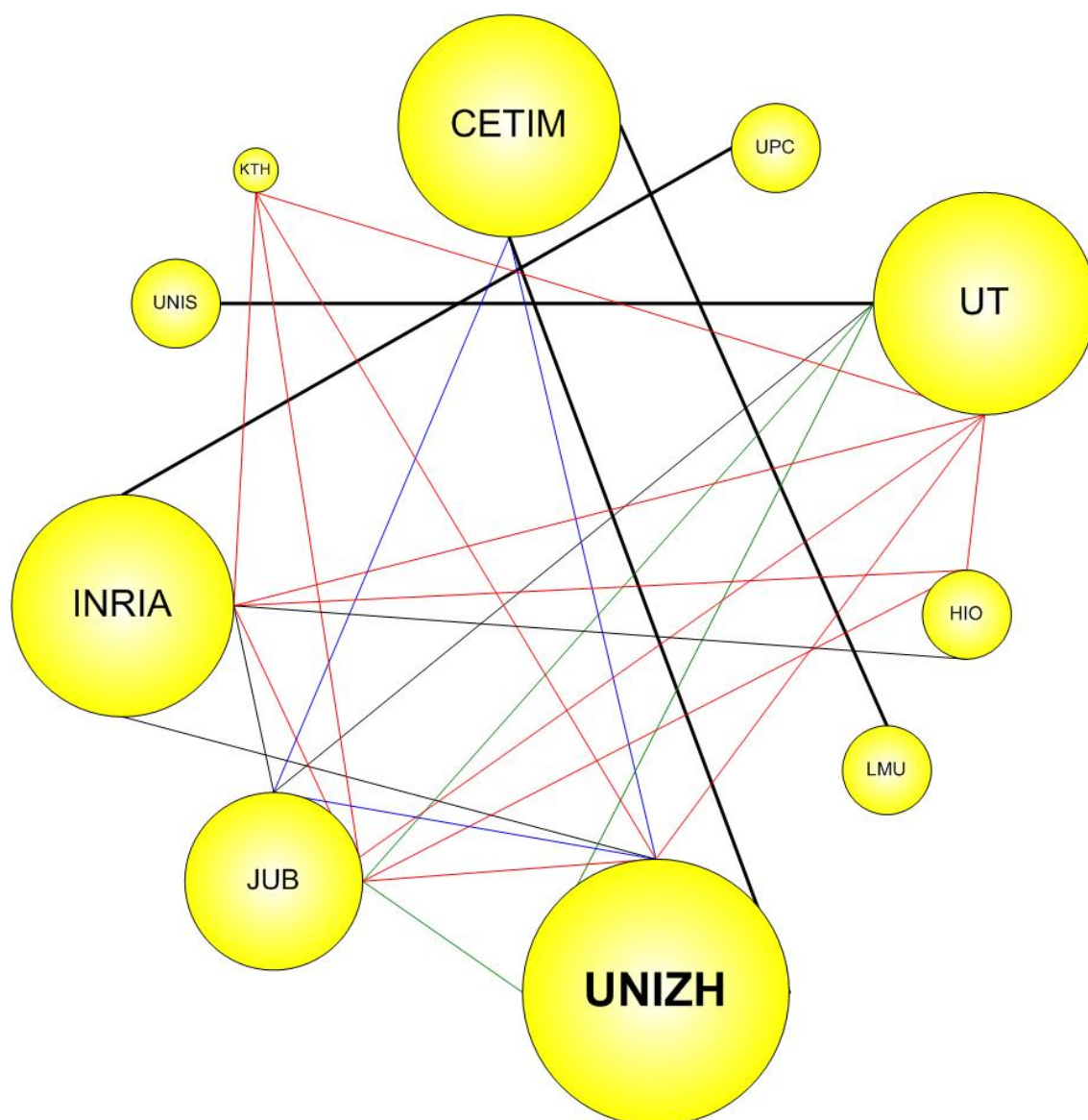


Figure 3: EMANICS joint papers

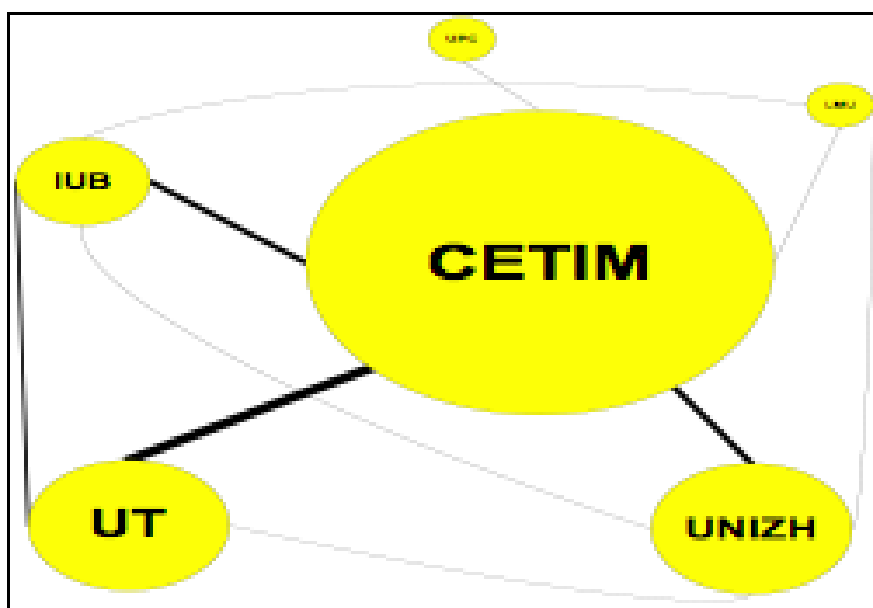


Figure 4: Integration within work packages: work package 1

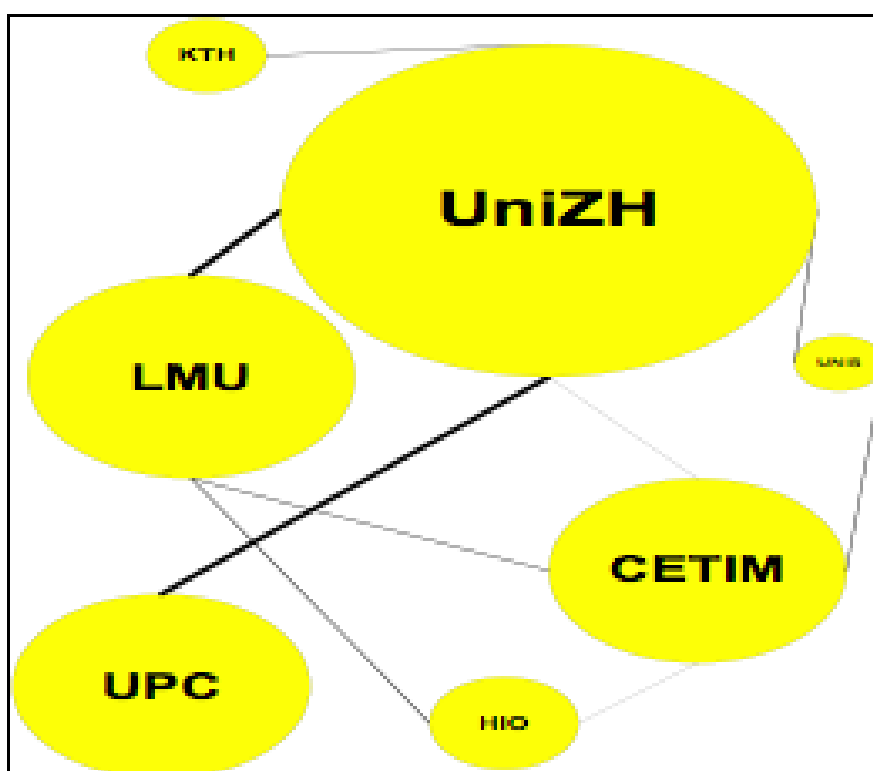


Figure 5: Integration within work packages: work package 8

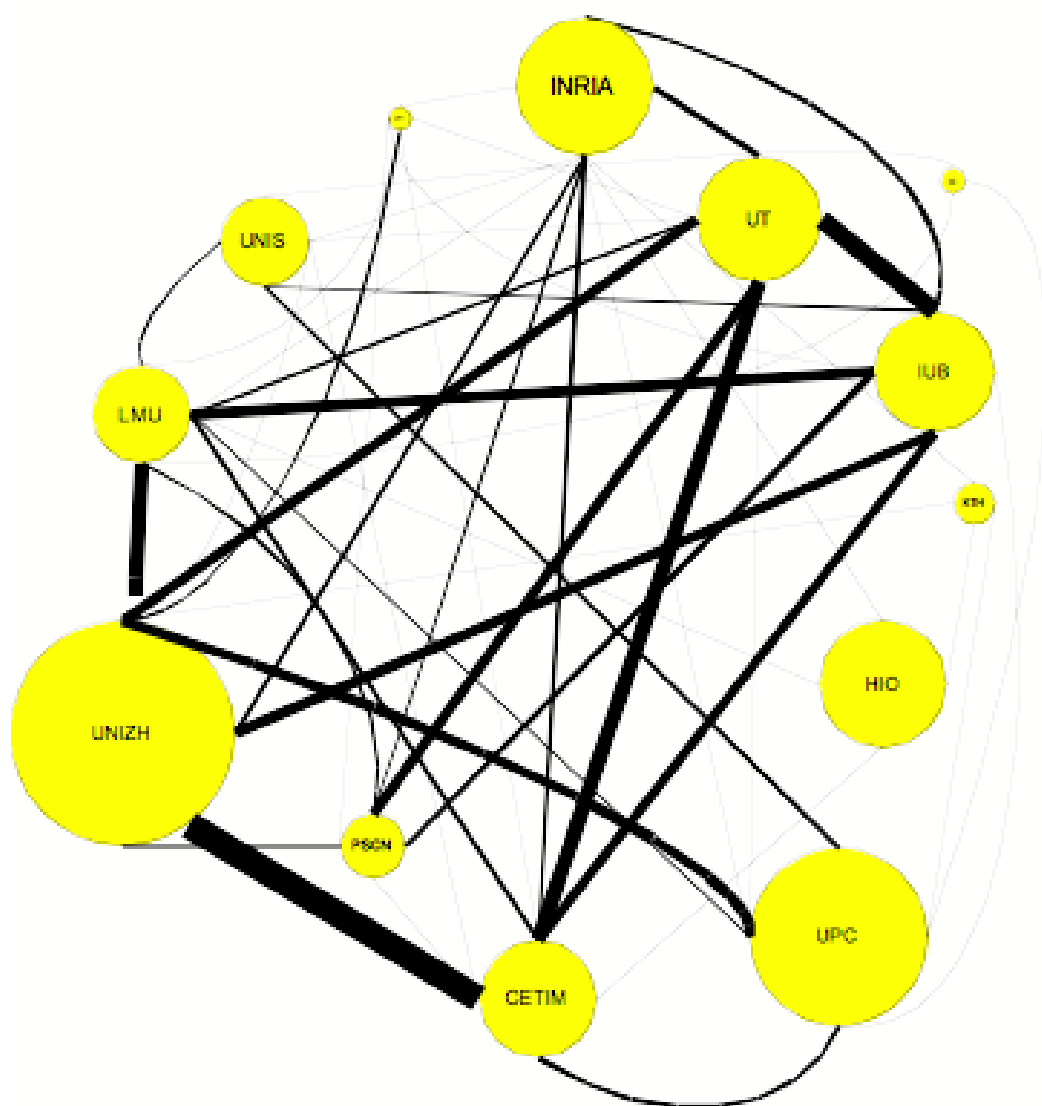


Figure 6: EMANICS integration within work packages: all



## 5 Worldwide Research Map (WwRM)

The EMANICS partners have identified several goals for the WwRM:

1. Searching for people or institutions in order to find researchers for paper reviews. At the beginning the search is restricted to topics of interest of TPC members of conferences, workshops and journals, as stored in the JEMS database.
2. Strengthen project collaboration.
3. Find project/collaboration partners from other research areas - research database for the EU.
4. Find project/collaboration partners in the area of network and service management - looking for research group profiles/expertise by means of an IFIP and simpleweb wiki combination.
5. PhD students/researchers would like to find experts in (their own) field of expertise. This could be realized via JEMS, EMANICS wiki and IFIP wiki as well as a list of PhD theses.
6. Student/PhD students/researchers exchange programs.
7. Lists of planned, current and already finished research projects.
8. Collaboration between research groups/measurement of the degree of integration (optional).
9. Identification of adequate integration metrics (optional).

### 5.1 Tools: JEMS, EMANICS wiki, PhD database , IFIP/simpleweb wiki

#### 5.1.1 JEMS

The *Journal and Event Management System (JEMS)* is a database in the field of IT management to submit papers or reviews. JEMS is maintained by the Computer Networks Group (CNG) of the Federal University of Rio Grande do Sul (UFRGS) and provided as a service to organizers of conferences. The data stored in JEMS provides an adequate means in order to extend the research map and to solve some of the problems mentioned below.

JEMS has been used already for several years to handle the processes of paper submission, reviews, and selections of the major network and system management conferences like IM, NOMS, and workshops like DSOM. Having been in use since then, JEMS constitutes a valuable repository of papers, research topics, authors, reviewers, technical program committee members, and most importantly, their relationships.

Using JEMS in order to become a search engine of people working in the management area, a set of Tcl/Tk scripts has been coded and incorporated in the system. The main

feature developed in this context is the ability for a TPC chair, by providing a research topic in form of a keyword, to list all TPC members of all conferences hosted in JEMS that are interested in that respective research topic. A TPC member or reviewer can define his/her topics of interest and possible conflicts. For example, providing the keyword “self-management” will list all conferences and respective TPC members interested in self-management. This feature enables new TPC chairs to search for specialists on topics that he/she is considering as interesting for a specific new conference.

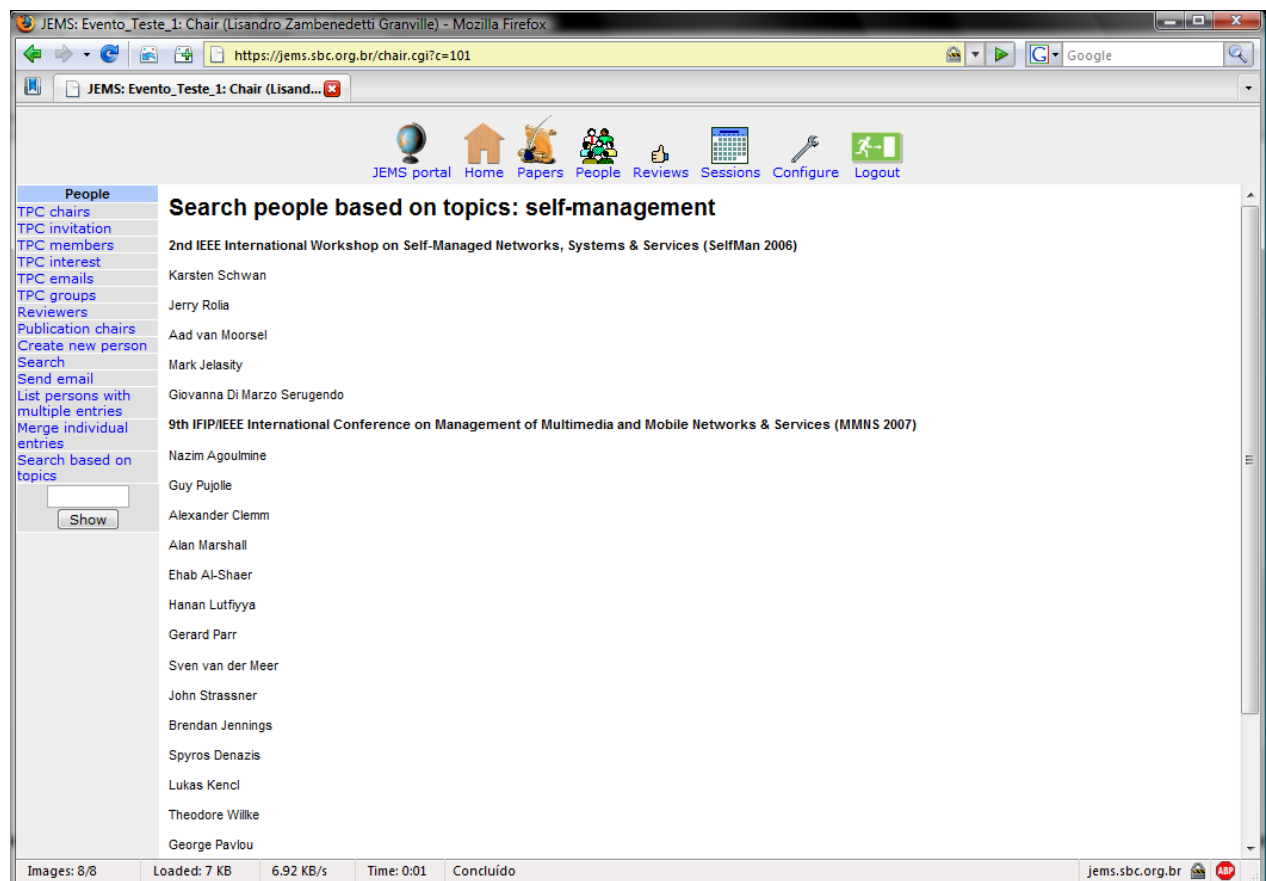


Figure 7: New search function in the JEMS system

Figure 7 shows an example of the use of JEMS for this purpose. After providing the keyword “self-management” the system lists, per conference, all TPC members that are interested in the specific topic.

## 5.2 Frontend: Google Maps

The long term goal within the NoE is to have a decentralized dynamically generated graphical map of researchers in the domain of network and service management worldwide. One challenge of generating this map is the collection of researchers’ data. This has to include most of the institutions, companies, universities, organizations and their associated researchers in IT Management. By using Google Maps, we had to assign for example research fields, projects, topics of interest to each of these communities according to their

location.

In the first stage of this task, we concentrated our efforts only on members within the NoE; thus, we started with a restriction of TPC members of most important conferences and locate them on the map in order to find researchers for reviewing papers, project partner, etc.

In that context, we noted several problems in the early design phase. Some of them are listed below:

- **Dynamic update:** A concept for the update of the data stored in the JEMS database and the WwRM database was defined. Since in the WwRM additional information is represented than available in the JEMS database, we selected the option to use a separate database for the WwRM and define the updates.
- **Temporally join of research groups:** Another problem that has to be dealt with, is that most of the researchers are joining and leaving affiliations frequently. The elapse of time is varying between one and five years of research work. Thus, it is important for conferences, journals and workshops that took place regularly, that every one or two years this map is updated periodically in order to find eligible TPC members and reviewers.
- **Heterogeneity:** There was a problem regarding the extraction of raw data because of its heterogeneity. The acquired information presents various types of data due to the fact that no standard for all participants or research people exists. For example, the location which is one of the most important criteria for the map is given in different forms; someone would write the name of the country but not his town or his city, someone else would write the name of the street or only the postal code etc. Thus, we can conclude that there is still a lot of work to do to solve this problem in order to be able to extract automatically useful data for the WwRM.
- **Updates:** Since a fast change of the research interests of an institution can easily occur, updates have to be done in a smooth and simple way by all partners involved to omit long delays and inconsistent information.

In the first stage of our work, we have analyzed and made the concept of the WwRM. In the second phase, we decided to establish and to implement two testbeds. The first one is using Google Maps spreadsheets, and the second one relies on the use of databases such as MySQL. The distinction makes sense once we have more than 1000 researchers of the map due to scalability issues.

The WwRM has to support an automatic update of data from the JEMS system on one side and manual entering and updating of data by researchers on the other side. The data structures for the data to be entered manually have been discussed among partners, and the outcomes will be presented in the next deliverable.

Furthermore, researchers who intend to join the map have not to face with complicated software and authorization problems so we have to keep it as simple, quick and secure as possible. Nevertheless, the access to the WwRM has to be controlled. It has to be ensured, that only authorized persons can read, insert and edit data. A concurrent access of several users at the same time has to be made possible such as to read data of the

own or other affiliations, and to insert and edit data of the own affiliation. Fig. 8 shows the Google Maps based front end.

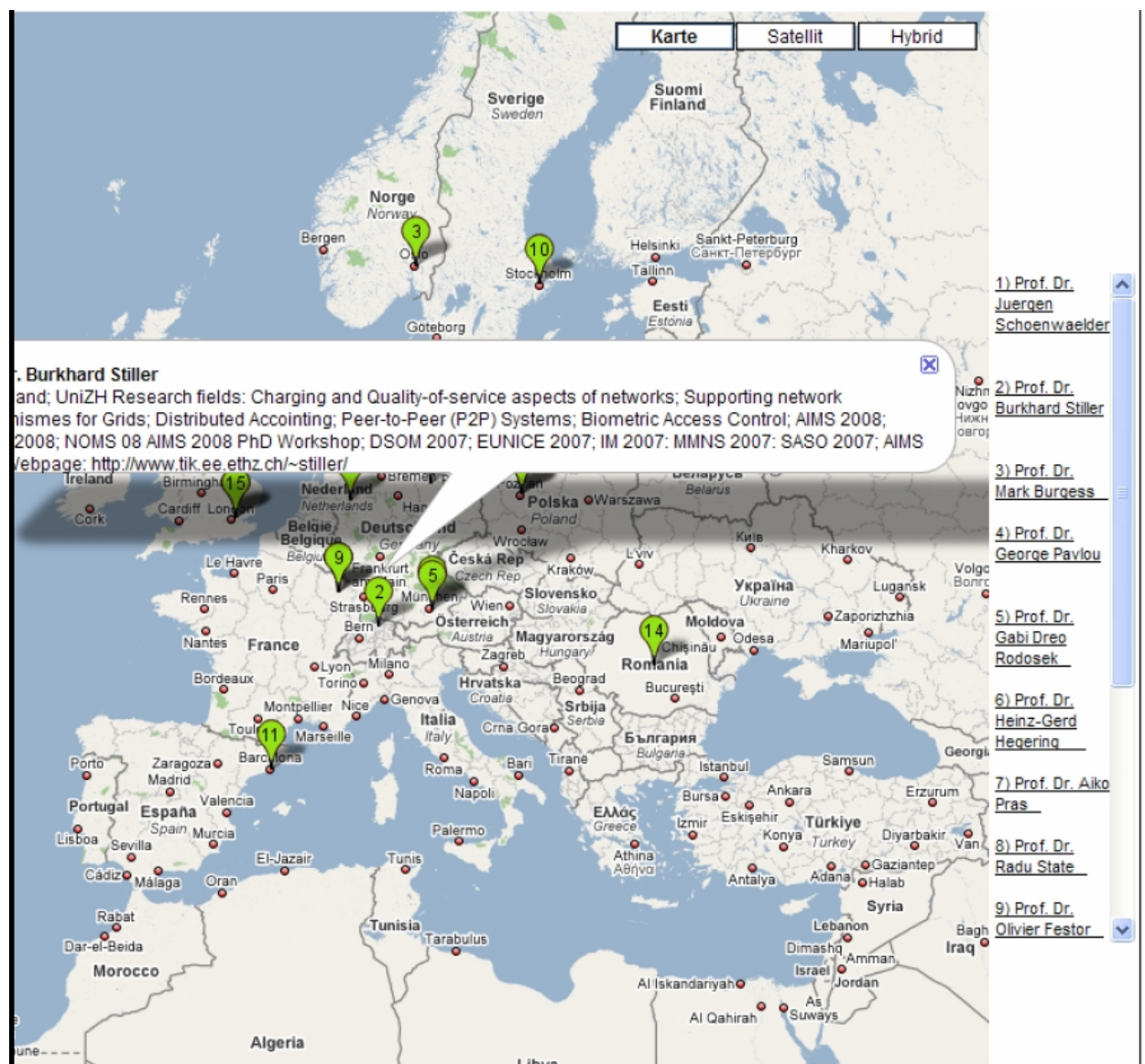


Figure 8: Google Maps front end

## 6 Taxonomy of Network and Service Management

As discussed within previous WP1 meetings, a comprehensive taxonomy of network and service management serves as an essential means in order to provide a common vocabulary for discussions inside as well as outside the Network of Excellence (NoE) which is based on a formal resp. structured representation of knowledge.

Additionally, the taxonomy allows for a better structuring and categorization of the modules of the Common Course Program (CCP) as well as related research activities in the domain of network and service management. Beside these aspects, the taxonomy fosters a common understanding within the EMANICS network so that semantics of exchanged concepts are commonly known between involved partners. Another benefit of the taxonomy is, that based on the classification of terms, research papers can be put into several categories in order to find appropriate experts for a specific topic, thus simplifying the overall review process. In October 2007, a further WP1 meeting took place in Munich addressing several aspects wrt. the taxonomy of IT network and service management.

The following presents a description of a classification approach for conference topics on network management which have been extracted from the JEMS conference management system [2] resulting in a classification of terms along with related elements.

### 6.1 Classification approach for conference topics on network management

#### 6.1.1 Description of presented approach

In order to better comprehend the set of relevant subjects being currently considered in network management research, a study about the topics of interest used in conferences in the area has been carried out. As a result of this study, a classification of the conference topics, in the form of a taxonomy, has been produced. The classification approach used in this work is presented below, and is divided in two parts: a top-down part and a bottom-up part.

##### Top-down part

In the top-down part a set of relevant "terms" (to distinguish from "topics" explained next) has been specified and organized in a hierarchy of two levels. First-level terms are more generic and broad, and cover a wider range of management aspects. "Service management" and "functional areas" are examples of first-level terms. Second-level terms, in turn, are more specific and cover more precisely a subject of the management research. Second-level terms are linked to higher, first-level terms and cover more specific subject in the management field. "Configuration management" and "security management" are examples of second-level terms linked to "functional areas", which is a first-level term as exemplified before.

## Bottom-up part

In the bottom-up part of the classification approach, the topics used in network management conferences have been observed. Different than the terms defined in our study, topics are defined by the chairs of the Technical Program Committees (TPCs). Each specific conference, despite belonging to the management field, presents topics in the Call for Papers that are different than the other conferences in the field. It means that the set of all topics in the management area is quite diverse and, not surprisingly, does not follow a specific pattern.

For each conference observed, all of its topics have been linked to terms defined in the top-down part of the approach mentioned before. Looking at terms and topics and their final relationship, topics become the third level of our classification hierarchy. For example, the topic "security protocols and privacy in IP networks" has been linked to the second-level term "security management".

In total, 408 topics have been classified linking them in the classification hierarchy. These 408 topics have been extracted from the following list of conferences, accessing the JEMS conference management system:

- IM 2005
- DSOM 2005
- IPOM 2005
- NOMS 2006
- IPOM 2006
- MMNS 2006
- IM 2007
- DSOM 2007
- IPOM 2007
- MMNS 2007
- NOMS 2008

### 6.1.2 Graphs and numbers

After having defined the hierarchy of terms and topics, a collection of graphs has been produced in order to evaluate the first versions of our hierarchy. We were specially interested in understanding the indirect interests of paper authors and conference TPC members in regard to the first and second-level terms. The following steps present how the first numbers and graphs have been computed:

1. Let's assume that  $to_1$ ,  $to_2$ , and  $to_3$  are three topics all associated to second-level term  $2Te$ ;
2. Let's also assume that  $to_{1_n}$ ,  $to_{2_n}$ , and  $to_{3_n}$  are the numbers papers associated to  $to_1$ ,  $to_2$ , and  $to_3$ , respectively. Since a single paper can be associated to more than one topic (e.g.,  $to_1$  and  $to_2$ ), the same paper may count several times along  $to_{1_n}$ ,  $to_{2_n}$ , and  $to_{3_n}$ ;
3. The number of papers indirectly associated to second-level term  $2Te$  is the sum  $2Te_n$  of  $to_{1_n}$ ,  $to_{2_n}$ , and  $to_{3_n}$ ;
4. The number of papers indirectly associated to first-level term  $1Te$  is the sum of papers indirectly associated to all second-level terms associated to term  $1Te$ .

The same holds for TPC members when we use them instead of submitted papers. Figure 9 presents the relative number of papers and TPC members for the first-level terms (first graph) and for all second-level terms organized in 6 graphs (Figure 10 to Figure 15, each one related to a first-level term). It is important to observe that these are intermediate results that allowed us to evaluate the terms originally defined and to improve our taxonomy to the point presented in the next subsection.

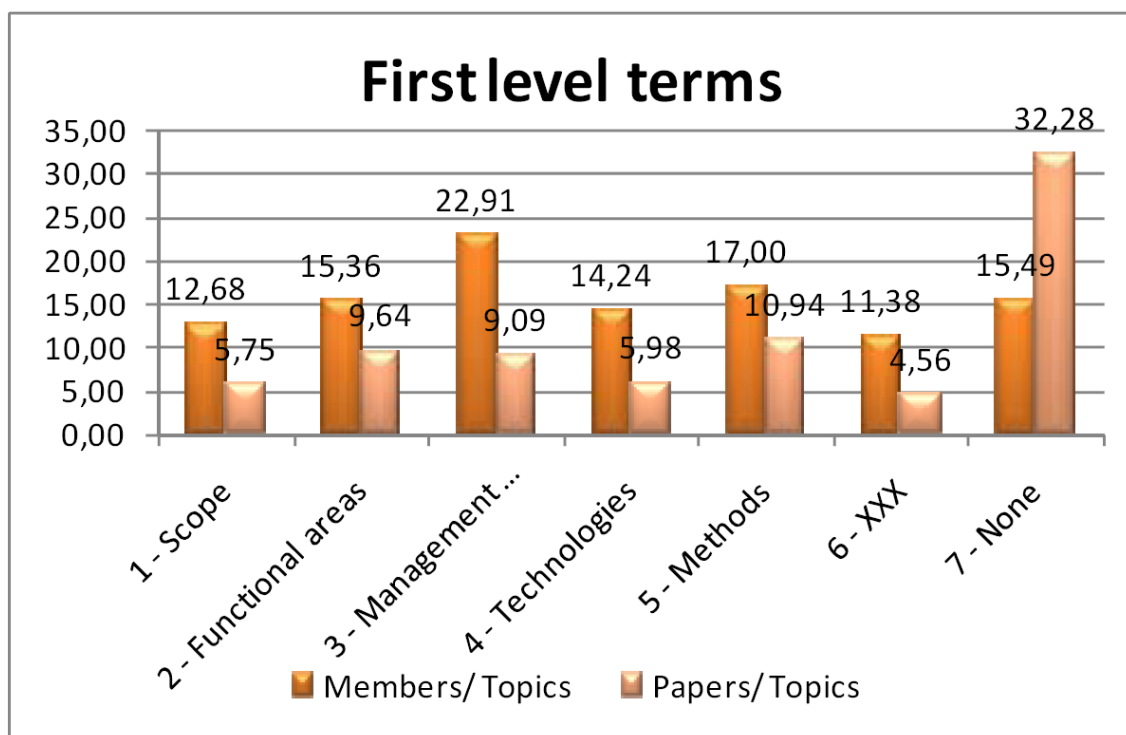


Figure 9: First Level Terms

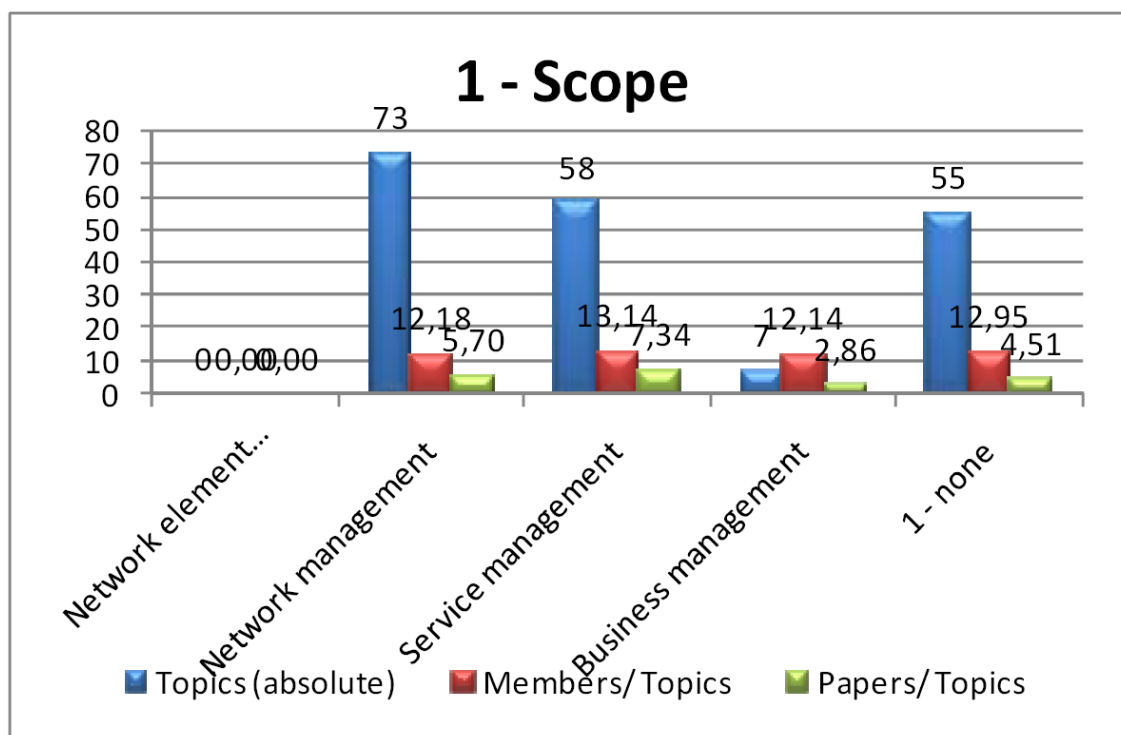


Figure 10: Scope

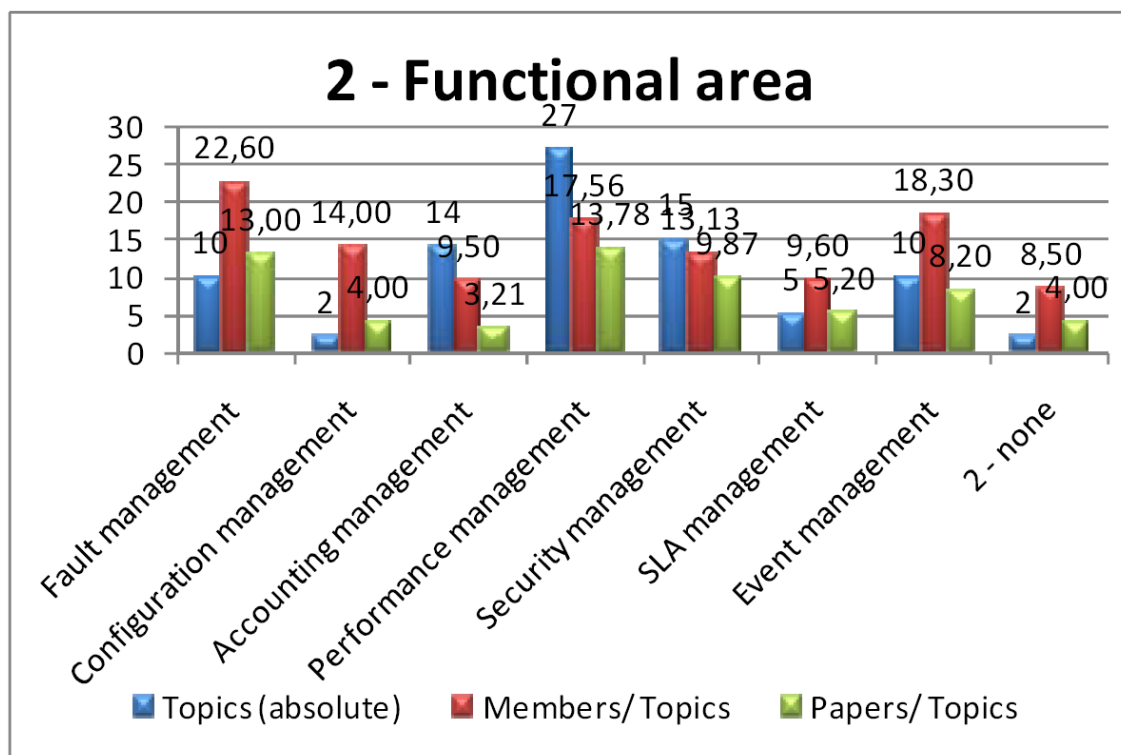


Figure 11: Functional Area



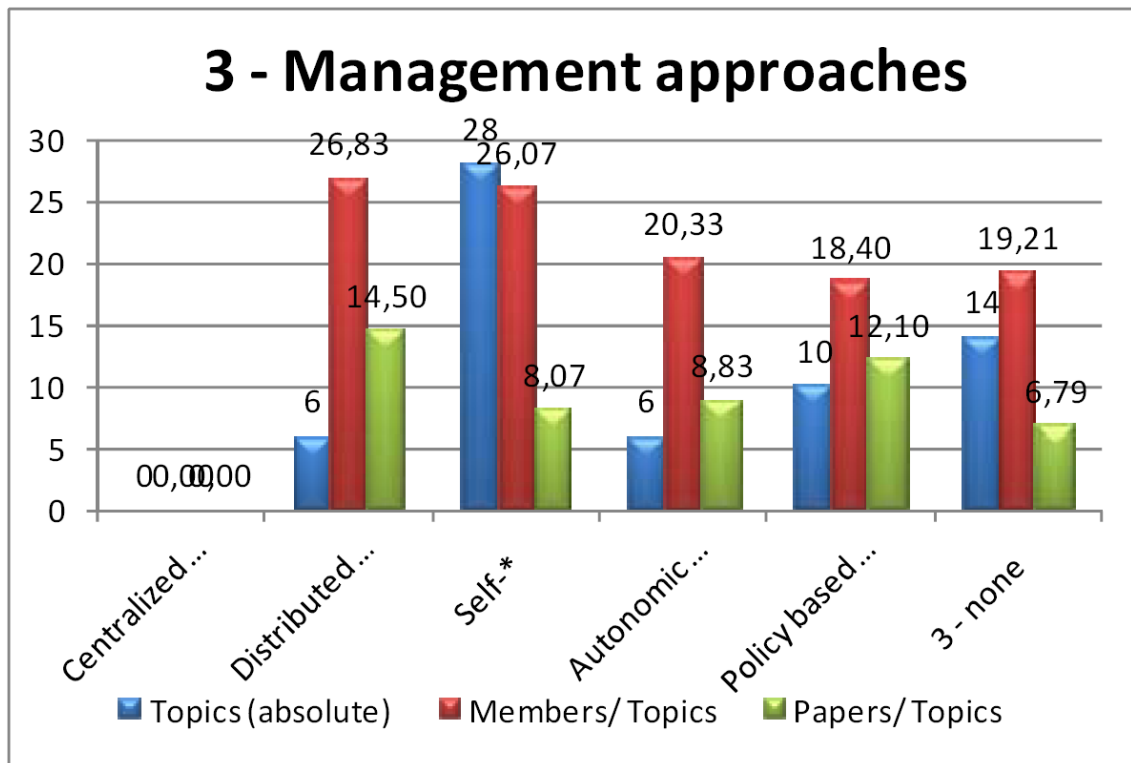


Figure 12: Management Approaches

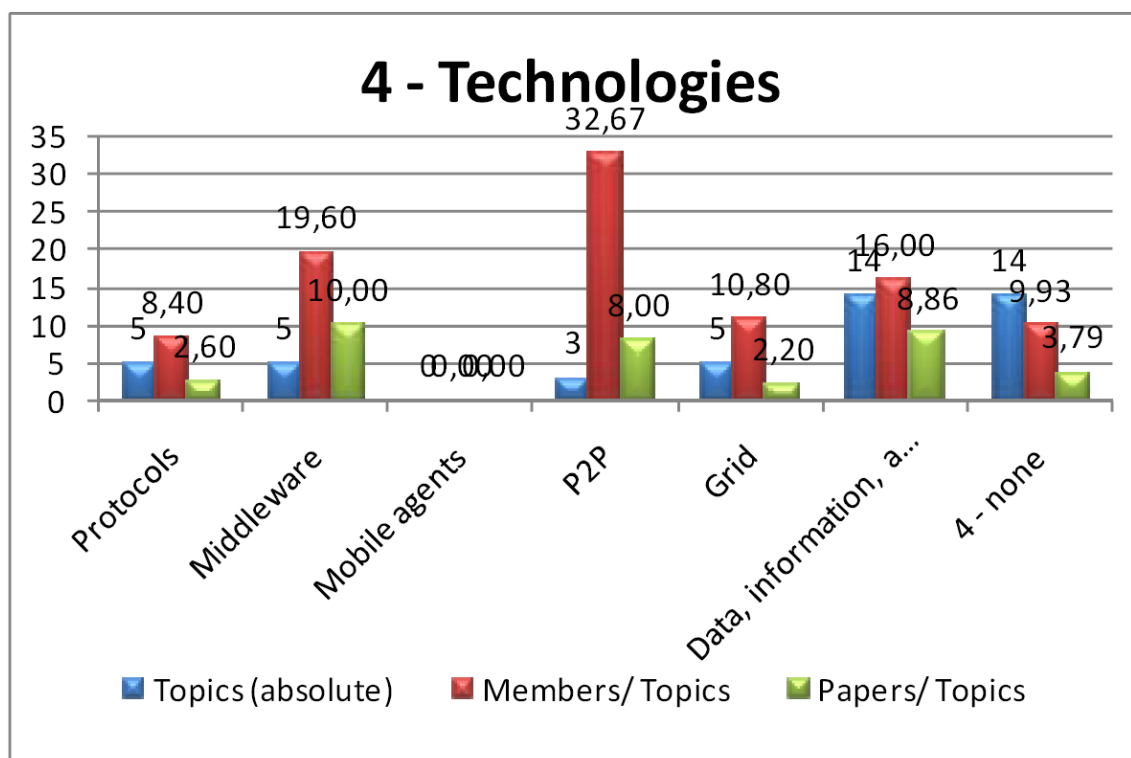


Figure 13: Technologies

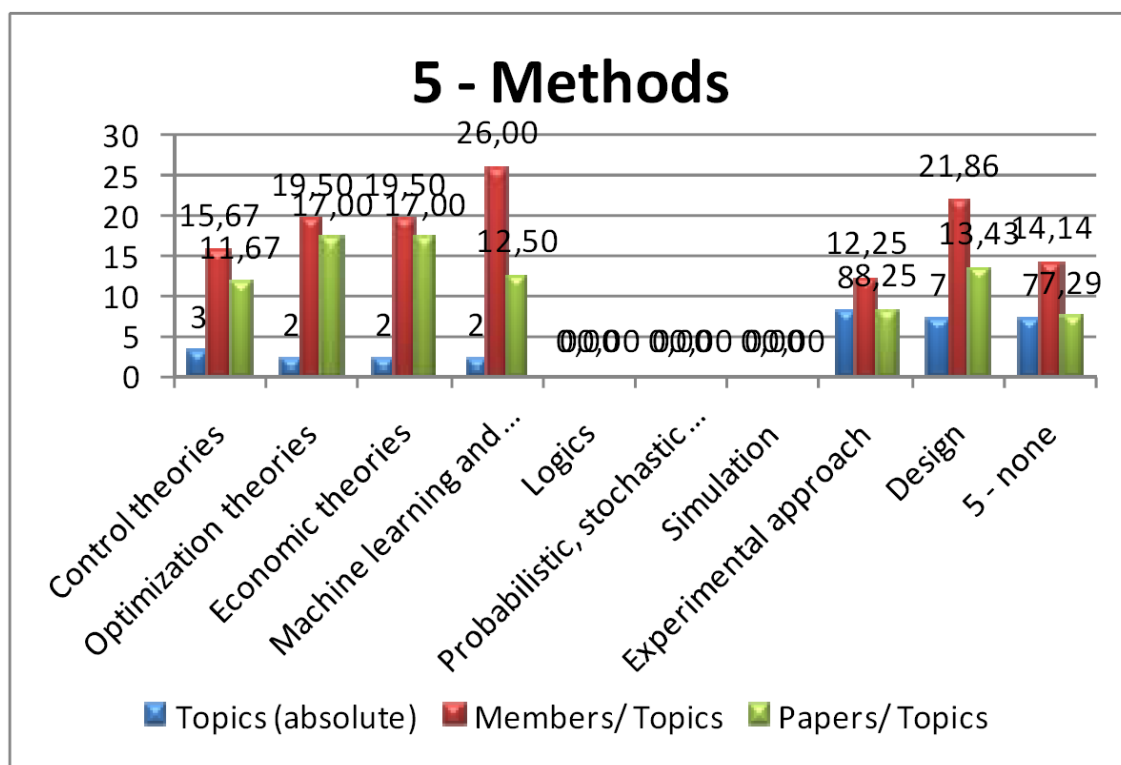


Figure 14: Methods

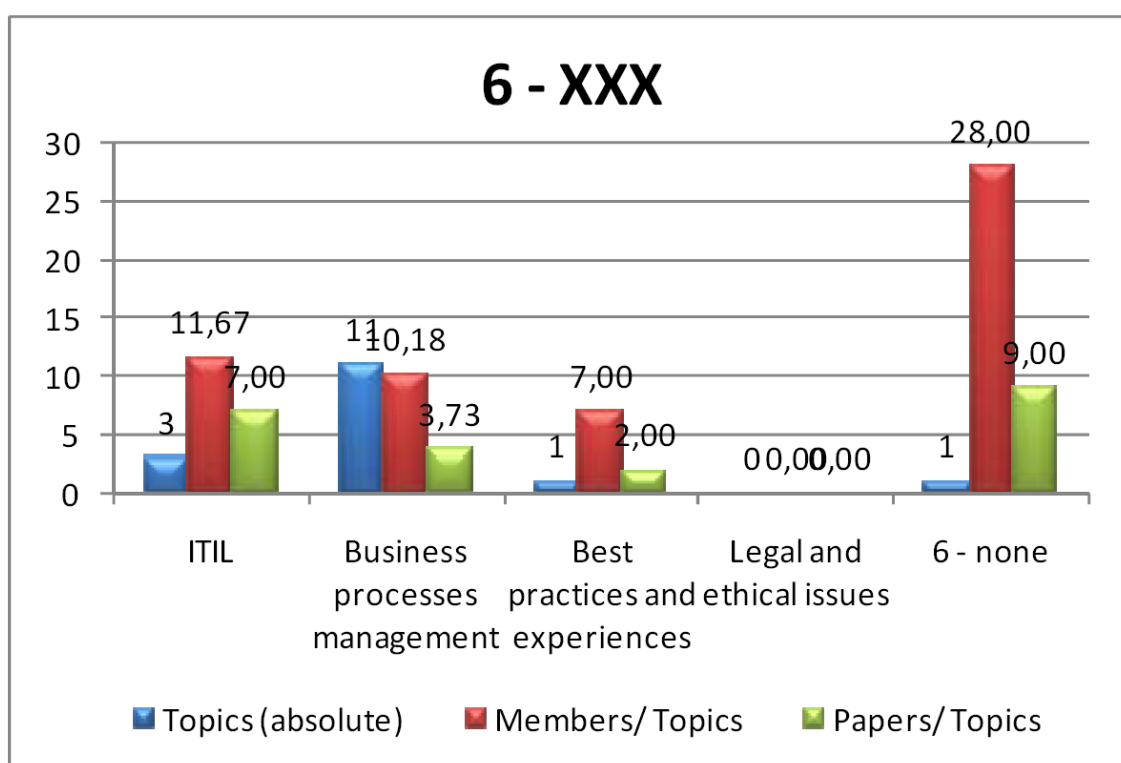


Figure 15: XXX

From these graphs, we draw the following intermediate conclusions:

1. First-level terms properly captured in a balanced way the TPC members interest and author's paper;
2. Some second-level terms may be too specific to cover some topics, e.g., the SNMP term;
3. Unclassified topics (refereed as a "none" second-level term) indicate that some areas needed additional second-level terms to be better covered.

## **6.2 Classification of terms**

Considering the study above, the final outcome of it is a final version of the network and service management taxonomy, as presented below:

### **6.2.1 Network management**

- Adhoc networks
- Wireless & mobile networks
- IP networks
- LANs
- Optical Networks
- Sensor Networks
- Overlay Networks

### **6.2.2 Service management**

- Multimedia Service Management (Voice, Video,...)
- Data Service (email, web, ...)
- "Hosting" (VMs, e.g. IBM terms in OCEANO)
- Grids

### **6.2.3 Business management**

- Legal & Ethical Issues
- Process Mgmt

#### **6.2.4 Functional areas**

- Fault management
- Configuration management
- Accounting management
- Performance management
- Security management
- SLA management
- Event management

#### **6.2.5 Approaches**

- Centralized management
- Distributed management
- Autonomic and self management
- Policy-based management

#### **6.2.6 Technologies**

- Protocols
- Middleware
- Mobile agents
- P2P
- Grid
- Data, information, and semantic modeling

#### **6.2.7 Methods**

- Control theories
- Optimization theories
- Economic theories
- Machine learning and genetic algorithms
- Logics

- Probabilistic, stochastic processes, queuing theory
- Simulation
- Experimental approach
- Design

## **7 Model Curriculum: M.Sc. in Network and Service Management**

This is not the final model curriculum as Deliverable 1.5 (due end of 2008) is meant to be the major deliverable on the common course program. In this report we give information about the purpose of a Master degree in network and service management, and the current status of design and description of the modules.

As stated in [3], one major objective of work package 1 is the establishment of an EMANICS common course curriculum in order to support a long term integration of the European teaching activities regarding network and service management. The EMANICS common course curriculum provides a quality label in the domain of network and service management and facilitates the exchange of students and researchers between European research institutions and universities. Similar to the definition of a model curriculum for the M.Sc. program in Information Systems [4], the EMANICS NoE proposes this curriculum for a M.Sc. program in the domain of network and service management.

### **7.1 Goal and intended audience of the model curriculum**

This model curriculum acts as a template for institutions that want to implement such a Master's program and it is not a program for a joint Master's program (e.g., Erasmus-Mundus).

This model curriculum for a Master's program in network and service management has the primary target audience of universities that are interested to set up such a program. The curriculum was developed based on the expertise of the partners of the Network of Excellence EMANICS - European Network of Excellence for the Management of Internet Technologies and Complex Services.

### **7.2 Purpose of the degree**

#### **7.2.1 Career options**

Career opportunities for IT professional are in a great variety of industry sectors. For graduates of the Master program in network and service management we especially envision the following fields of work:

- Network operator: strategic planning, evaluation of new technologies and the like
- Consulting
- Enterprise Networks
- Academic and (national) research networks
- Server hosting companies

- (Application) Service providers
- Academia
- Security audit companies
- Certification companies
- Governmental organizations
- Equipment and SW manufacturers

### **7.2.2 Learning targets / Objectives**

The M.Sc. in Network and Service Management program has the following objectives:

- To give the students knowledge and skills on architectures, protocols and techniques required as a basis for specialists in network and service management. This is achieved by providing a basic set of core lectures studied by the students during the first and second year. Technical topics are complemented by economic, legal and ethical aspects.
- To provide in-depth study and training in particular areas of the field by deepening substantial topics in the third year and to provide students with research and development skills through a substantial 6-month research and development project undertaken at the end of their studies.
- To provide the students with the following skills, knowledge, and values:
  - A core of knowledge in network and service management
  - Impact on and from adjacent disciplines
  - Real world experiences and perspectives
  - Analytical and critical thinking skills
  - Project management skills through steering the own thesis

### **7.3 Student background**

The Master program in network and service management is most appropriate for students with a bachelor degree (or comparable knowledge) in:

- Computer Science / Informatics
- Telematics
- Electrical Engineering
- Business Information Technology
- Mathematics
- And comparable degrees

## 7.4 Description of the Master program / Modules

Semester	Title	Description	ECTS
1	Internet Protocol and Services	Routing, MPLS, QoS, Multimedia, Signaling, Transport, Components	5
1	Mobile and Wireless Networks	GSM, UMTS, WLAN, WAP, DxB, MANET	5
1	Management Principles and Architectures	OSI, Internet-Mgmt, TMN, Distributed Mgmt, Autonomic Mgmt, Policy-based Mgmt	5
1	Network and Information Security	Cryptography, Privacy, Security protocols, System security, IDS, IPS, Firewalls, Anonymity, Scanning, Rootkits	5
1	Performance Analysis	Queuing theory, simulation, stochastics, fluid models	5
2	Economic Aspects of Management	Accounting, SLA, Pricing, Tariffing, Metering, Billing	5
2	Social, Legal & Ethical Issues in Management	Computing ethics, codes of ethics, organizations, regulation, computer crime, social implications	5
2	Traffic Engineering	Internet services (e.g. VoIP, IPTV, video communications), DiffServ, IntServ, MPLS), resource provisioning, traffic shaping, scheduling)	5
2	Distributed Algorithms	Models, Synchronous message-passing distributed systems, atomic commitment problem, Byzantine Generals problem	5
2	IT Service Management	ITIL, eTOM/NGOSS, Workflow management, Incident mgmt, Change mgmt, Release mgmt, Trouble mgmt	5
3	Advanced Topics	Policy-based mgmt, Promise theory, Control theory, Autonomic management, Event correlation	5
3	Lab: Networks	Protocols, switching, routing, components	10
3	Lab: Network Management	Security, Netflow, measurement, Mgmt tools	10
3	Internship	replaces second lab	10
3	Seminar		5
3	Thesis Proposal		10
4	Master Thesis		30
	<b>Summary</b>		<b>120</b>



## 7.5 Course descriptions

The course descriptions are intended as specifications to be used by individual instructors in preparing course syllabi. Universities and institutions will, of course, tailor courses to their strengths and the needs of their students.

**Name: Internet Protocols and Services (NSM01)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* The communication among computers hosting the services, and those users requiring them are based on communications protocols. These protocols standardize the way the information flows from one computer to other. Many of them are oriented to particular services, such as electronic mail, video and audio applications, or just information transfer between remote places. This course presents the background behind the protocols and services used on Internet applications and some of the details required to understand the functionality and the potential of the protocols.

The following contents are addressed: media access mechanisms, routing algorithms, error detection and correction, flow and congestion control mechanisms, data representation. The fundamental algorithms and principles are explained in the context of existing Internet protocols in order to demonstrate how fundamental results are used in real-world protocols.

**Name: Mobile and Wireless Networks (NSM02)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* Students will get enhanced insight into mobile and wireless communication systems. Contents feature up-to-date and future technology and systems and their evolution over time. The course will develop the fundamental concepts in mobile and wireless networks; the different access technologies, handoff control and mobility management protocols, and existing and emerging applications. Students will learn the key design issues in networks supporting traditional voice applications as well as data communication from very small distances to wide area networks.

Based on fundamental knowledge about networks and distributed systems, this course teaches the following contents: basic principles, wireless transmission, media access control, wireless telecommunication systems such as GSM, 3G, DECT, UMTS, satellite systems, broadcast networks, wireless local networks, ad-hoc networking, and mobility management.

**Name: Management Principles and Architectures (NSM03)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* This course introduces fundamental principles and architectures for network and management that have evolved during the last 20 years. This course provides fundamental prerequisites for more specialized courses of the program. While some concrete technologies will be introduced as part of the course, these technologies will only serve as

examples demonstrating how principles and architectural concepts are used in practice.

The course covers the following topics: OSI management framework and architectural concepts, TMN architectural concepts, Internet management frameworks and protocols, distributed management approaches, policy based management frameworks and policy languages.

**Name: Network and Information Security (NSM04)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* The aim of this course is to provide an introduction to the theory and concepts of security, as applied to computer systems. At the end of the course, a student will have an understanding of the themes and challenges of network security, the role of cryptography, the techniques for access control and intrusion detection & prevention, and methods to ensure privacy and anonymity.

The following topics will be addressed: security engineering, fundamentals of cryptography, public-key and private-key cryptography, digital signatures, Internet security, intrusion detection and prevention, firewalls, privacy, trust, and anonymity.

**Name: Performance Analysis (NSM05)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* The course focuses on modelling and analyzing communication networks, network protocols and applications, using mathematical tools. By the end of the course students will be able to construct tractable models of complex networking problems and attack performance problems with analytical methods or simulation. These abilities are necessary for everyone working on technical fields - to understand the capabilities of specific technologies and the success or failure of new trends.

The course addresses performance issues in current and future Internet architectures: multi-access communication: CSMA/CD - reservation techniques (token and polling) - packet radio networks (WLANs), routing in data networks: shortest path routing - optimal routing and topology design, flow control (TCP), Quality of service (QoS) in IP networks: requirements for multimedia transmission - network support: scheduling, shaping, forward error correction.

**Name: Economic Aspects of Management (NSM06)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* In order to support commercialization of resources and services, a viable service infrastructure must be in place, which is responsible for economic aspects of network and service management. This course aims at providing students with detail knowledge about these economic aspects which include various schemes to price usage of resources and services offered, as well as mechanisms and technologies to collect usage data and get payments. The course will also introduce service level agreements as an important instrument to hold and legally bind contractual commitments of a service provider to a customer.

Different types of tariffs, i.e., flat-rate, usage-based tariff, as well as their combination (e.g., Cumulus Pricing Scheme) will be described in this course along with a discussion on their appropriateness for pricing various resources and services. A tariff formula can be derived from costs for resource or service provisioning, market demands, or a combination of both. Concerning mechanisms for collecting usage data and getting payments, students will learn about usage metering, accounting, charging, and billing, while discussions about their technology will comprise architectures (AAA, IMS), protocols (RADIUS, Diameter), and tools (NetraMet, NetFlow, OpenDiameter).

**Name: Social, legal and ethical issues in Management (NSM07)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* The aim of this course is to make you reflect on social, cultural and ethical issues surrounding society and its use of information technology. One aim is to increase the student's awareness of the implications computer technology have on the development of our society. They should realise the responsibility they have as computer professionals to give realistic information about technological possibilities and limitations to the public. They should know pro and con arguments of major issues related to the use of computers and the Internet, and be able to argue orally and in writing. They should be able to ethically evaluate the products of their future employer, whether they work in business, research or education.

Second, the students should gain knowledge of the laws and regulations concerning the use of computers and networks. Topics include: intellectual property, copyright protection, patent law, and computer crime and also covers differences between systems in Europe and worldwide.

**Name: Traffic Engineering (NSM08)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* Traffic engineering is mainly concerned with the planning of communication networks so that they can handle the traffic demands considering the quality of service demands and balancing the costs of the communication infrastructure. This is in particular important for real-time services (multimedia, gaming) or services requiring high availability guarantees or low error rates.

The course will introduce basic traffic management mechanisms (fair scheduling algorithms, traffic shaping mechanisms), technologies (integrated services, differentiated services, MPLS), and explain how analysis techniques (queuing theory, fluid models, simulation models) can be used to engineer the quality of service provided by a network.

**Name: Distributed Algorithms (NSM09)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* The course deals with basic distributed algorithms that are underlying many distributed applications and network protocols. The first goal of the course is to provide students with a good overview of possible solutions to frequently reoccurring problems

in the design of distributed systems. In addition, the course aims at developing a sound framework and methodology for formulating and analyzing distributed algorithms.

The course covers the following topics: synchronous vs. asynchronous distributed systems, clocks and time, causality, wave and traversal algorithms, election algorithms, termination detection algorithms, snapshot algorithms, stabilization algorithms, distributed hash tables, synchronization algorithms.

**Name: IT Service Management (NSM10)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* Providing IT services to customers with better, guaranteed quality has been the aim of many diverse efforts, undertaken under the common denominator "IT Service Management". Lately, more organizational approaches to this issue have been gaining popularity, especially the guidelines of the IT Infrastructure Library (ITIL). Both the ISO/IEC 20000 standard as well as the Microsoft Operations Framework (MOF) are highly based on the ITIL contents. While ITIL has been developed and published by the British Office of Government Commerce (OGC) and in this respect can be seen as a collection of best practices, the Enhanced Telecom Operations Map (eTOM) is a research effort in the context of the NGOSS (New Generation Operations Systems and Software) project on behalf of the Tele Management Forum (TMF). All of the presented approaches follow the principles of process-orientation which basically means that the control of activities and operations in IT Service Management (ITSM) within an IT organization takes place in the context of dedicated management processes.

The learning targets are to be aware of the challenges in ITSM and business alignment of IT operations, to know the principles of process-orientation adapted to the management of IT and IT service operations, to gain a survey on state-of-the-art technologies and concepts in ITSM and to know the differences and interrelationships between the most important approaches.

**Name: Advanced Topics (NSM11)**

*Type:* Lecture

*Credits:* 5 ECTS

*Description:* This module adds in-depth treatment of one or more advanced topics, most of which focus on specific aspects of automation of IT management.

Automation of IT management shifts tasks formerly done by human administrators to a resource or service management system. While monitoring and execution are already mostly handled with machine support, a lot is left to be desired regarding analysis, planning and decisions. Several techniques are investigated to model and implement the tasks mentioned before.

**Name: Lab: Networks (NSM12)**

*Type:* Lab course

*Credits:* 10 ECTS

*Description:* The aim of this course is to give students substantial experience in using network equipment in a realistic environment. Students should become proficient at handling

hardware and software, as well as learn debugging skills. This will give practical experience with routing, switching and other networking technologies and students develop systematic experimentation skills and report writing.

The course targets the following topics: network protocols, OSI layers, network infrastructure, router configuration, monitoring and security (e.g. firewalls, access control, virtual private networks).

**Name: Lab: Network Management (NSM13)**

*Type:* Lab course

*Credits:* 10 ECTS

*Description:* The aim of this course is to give students substantial experience in using managing networks in a realistic environment. Students should become proficient at handling hardware and software, as well as learn debugging skills.

The following topics are covered: OSI management, SNMP and MIBs, SMI, installation and use of management tools, analysis and troubleshooting.

**Name: Internship (NSM14)**

*Type:* Lab course

*Credits:* 10 ECTS

*Description:* Instead of attending the second lab course, the student can work as an intern at a qualified company or research institution. Details have to be decided on a case-by-case basis.

**Name: Seminar (NSM15)**

*Type:* Seminar

*Credits:* 5 ECTS

*Description:* Seminars will usually be focused on a relevant and up-to-date topic that is not covered in great detail in the lectures. The course involves preparatory reading and the preparation of one particular subject by each student. The student deliverables include the oral presentation of her topic to the audience, followed by a discussion and a written report.

**Name: Thesis Proposal (NSM16)**

*Type:* Thesis

*Credits:* 10 ECTS

*Description:* One outcome of this Master program is a thesis that will be completed in the spring semester. Thus, in the previous semester a research topic has to be identified. Then each student has to find a supervisor, understand the background of the project, develop or adapt an appropriate methodology, and summarize the state of the project as a thesis proposal.

The purpose of writing a thesis proposal is to demonstrate that the thesis topic addresses a significant problem and that an organized plan is in place to help solve the problem. This will help in regarding the thesis as your most important project during your studies and apply appropriate project management techniques to accomplish the best possible result.

*Name:* **Master Thesis (NSM17)**

*Type:* Thesis

*Credits:* 30 ECTS

*Description:* The thesis project allows the student to manifest that she or he has acquired mastery of the design of network services and systems. Many projects will be part of ongoing research projects, but we will also invite industrial projects that meet our expectations in testing the skills and knowledge of the student. The projects are expected to lead to publishable results and are hence also a first step on a continuation towards a research career.

The thesis work requires the student to plan, execute and document the project work in a professional manner. The expectation is that the student will demonstrate the highest standard of work that he or she is able to perform.

## 8 EMANICS Visibility and Conclusions

### 8.1 EMANICS visibility

EMANICS has increased and still is increasing its visibility, and the NoE is evolving and integrating faster than expected. Fig. 16 shows some of the visibility aspects. Members of EMANICS hold for example the most important positions in the steering committees as well as chair and TPC positions in the flagship conferences in network and service management (IM, NOMS, MANWEEK), IRTF/NMRG, IFIP WG 6.6., editorial boards of prominent journals etc.

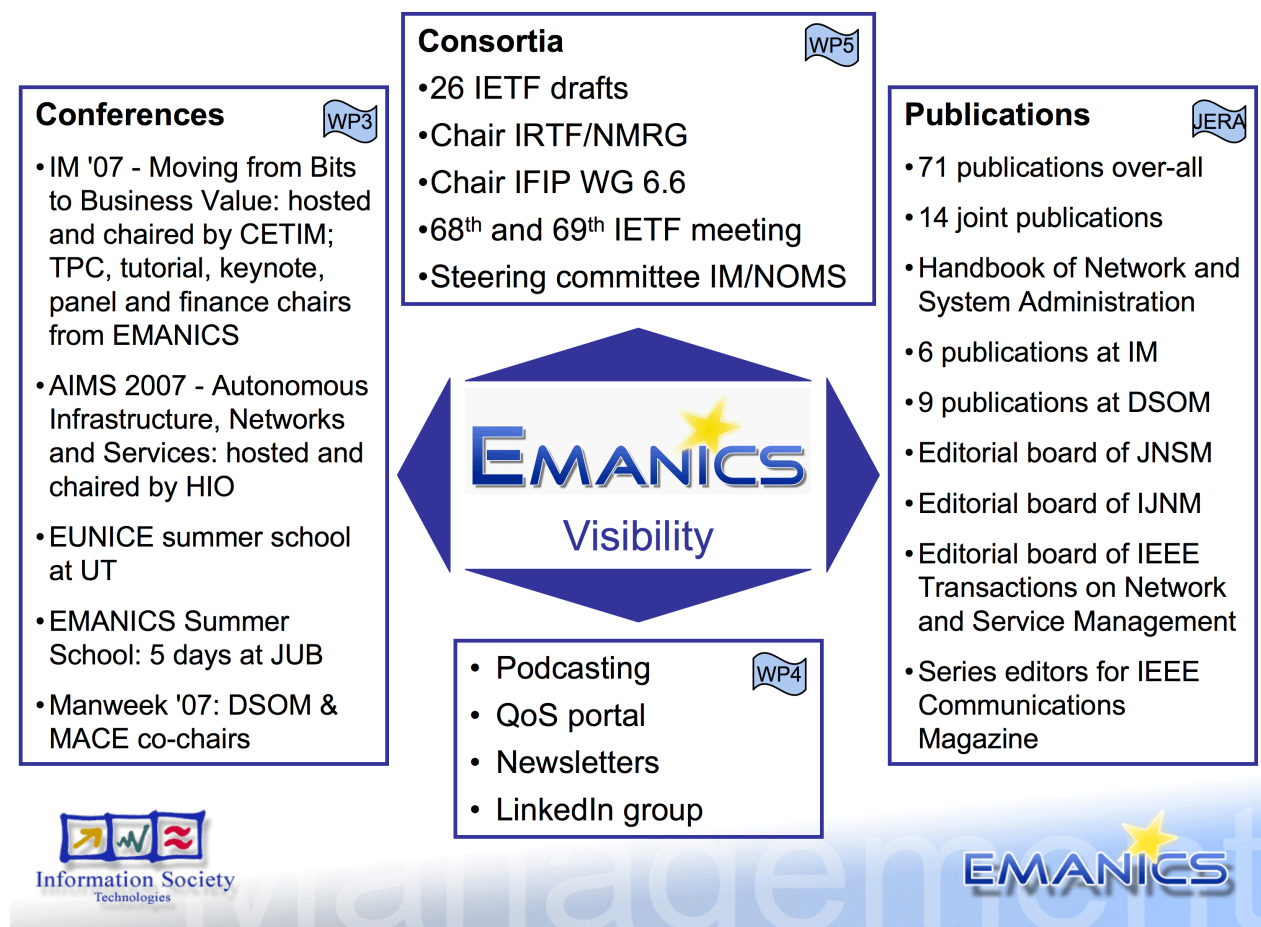


Figure 16: EMANICS visibility

### 8.2 Conclusions

The open-call based model stipulated task-based collaboration between the EMANICS partners to achieve the goals of work package 1. The Ph.D database published at the EMANICS web site serves two main purposes. First, it fosters awareness among EMANICS

PhD students about the work of their colleagues from partner institutions. This strengthens the collaboration and facilitates the integration as one main objective of the EMANICS NoE. Second, this information is open to the public and thus enhances the visibility of EMANICS work and topics in the relevant communities. In addition, we plan to integrate the PhD database to the Simpleweb and encourage researcher from other institutions worldwide to add their data.

Two actions have been undertaken to observe research worldwide. On one hand, JEMS has been extended by a set of scripts to add a new feature, it has also become a search engine for people working in the area of network and service management. On the other hand, a Google-Map-based front end showing researchers in IT management worldwide has been implemented. The work towards an ontology for network and service management has also been continued. Significant progress has been made by combining a top-down definition that delivered relevant terms from JEMS with a bottom-up part. There, topics defined by TPC chairs, have been collected from JEMS to identify the most relevant subjects. This two-step approach resulted in a classification of relevant terms for the taxonomy on network and service management. The work regarding the common course program for a Master program in network and service management resulted in an outline for the entire structure of the document and general information. 17 modules were defined and described that form a well-balanced model curriculum integrating the expertise of all partners of the EMANICS network of excellence.



## 9 Abbreviations

CCP	Common Course Program
CMS	Content Management System
ECTS	European Credit Transfer and Accumulation System
EMIN	EMANICS Integration Reporting Tool
JEMS	Journal and Event Management System
NoE	Network of Excellence

## 10 Acknowledgement

This deliverable was made possible due to the large and open help of the WP1 Partners of the EMANICS NoE. Many thanks to all of them.

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